Smart Agents and Sentiment in the Heterogeneous Agent Model

by Lukáš Vácha, Jozef Baruník and Miloslav Vošvrda

'Smart traders' is a new concept for improving the usual models for future price movements in financial markets. The influence of the proposed smart traders concept is examined with simulations.

An important feature of heterogeneous agent models (HAM) is their ability to explain stylized facts observed in financial time series, mainly fat tails and volatility clustering. Typically, in the heterogeneous agent's model, two types of agents are distinguished: fundamentalists and chartists. Fundamentalists base their expectations about future asset prices and their trading strategies on market fundamentals and economic factors, such as dividends, earnings, macroeconomic growth, and unemployment rates. Chartists or technical analysts try to extrapolate observed price patterns, such as trends, and exploit these patterns in their investment decisions.

We introduce a new concept – smart traders. The idea of smart traders is based on the endeavour of market agents to estimate future price movements. By adding smart traders we try to improve the original heterogeneous agent's model so it can better approximate real markets. Smart traders are designed to forecast the future trend parameter of price deviations using information sets consisting of past deviations. For simplicity, they are modelled to assume that the price deviations, defined by the model, are an AR(1) process and they use the maximum likelihood estimation method for forecasting. Thus, in our model we use two groups of traders: smart traders and a group of stochastically generated trading strategies.

Furthermore, we introduce changes in sentiment, which we define as a shift in beliefs about the future trend of a new investor strategy on the market. This allows us to model trend-followers and contrarians. In this work we use only the form of jumps in sentiment. Our main expectation is that the introduction of smart traders and changes in sentiment will change the simulated market prices significantly.

Model

The model presents a form of evolutionary dynamics called the Adaptive Belief System in a simple present discounted-value pricing model. Simulated capital market is a system of interacting agents who immediately process new information. Agents adapt their predictions by choosing from a limited number of beliefs. Each belief (trading
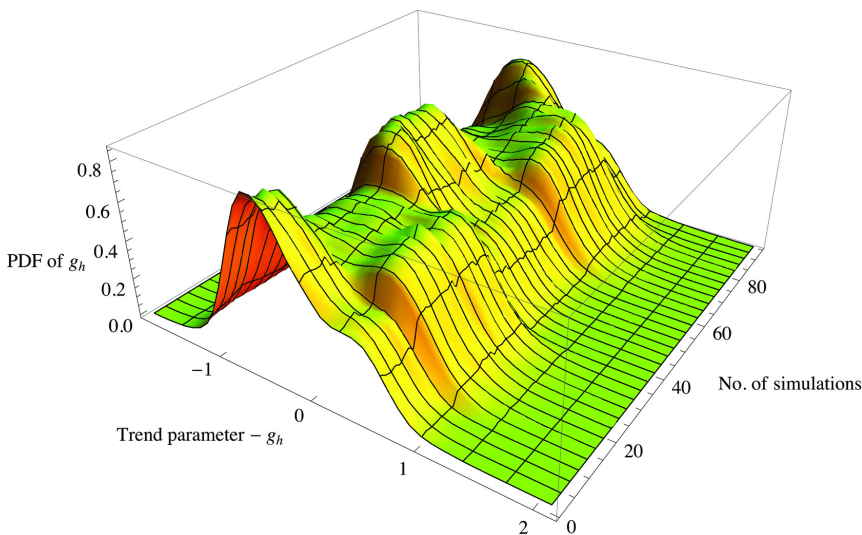

Figure 1: Empirical PDF of the trend parameter - g_h on the market through the iterations with the sentiment change.
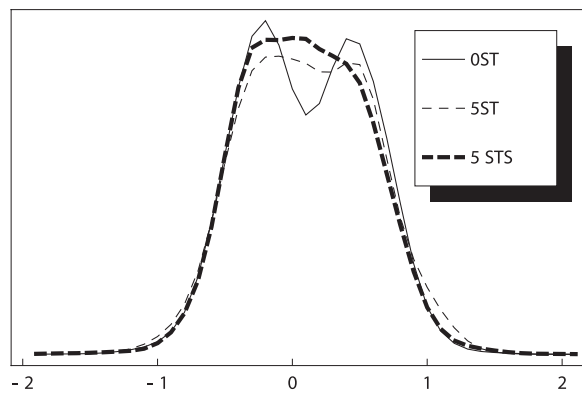

Figure 2: Empirical PDF of X(t) for simulated models without smart traders, with five smart traders, and with five smart traders and changing sentiment.
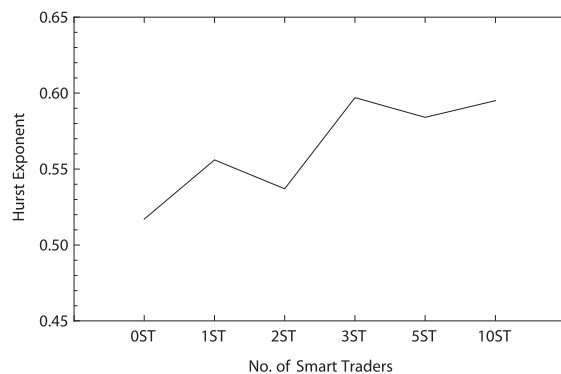

*Figure 3:
Hurst exponent of returns for different numbers of smart traders.*

strategy) is evaluated by a performance measure. Agents on the capital market use this performance measure to make a rational choice that depends on the heterogeneity in agent information.

Simulation Results

The main purpose of the simulations is to examine the influence of the proposed smart traders concept and changes in sentiment on the simulated market prices. We compare the model without smart traders (0ST) with the model with five smart traders (5ST) and the model with five smart traders in the first group and changes in sentiment in the second group (5STS).

Altogether we consider 40 trading strategies for each simulation. Figure 1 shows the empirical probability density function of the trend parameter observed on the simulated market with sentiment change. It is the cross-section through the iterations, and the changes in sentiment can be clearly observed. Each model has been simulated 36 times to achieve robust results. Figure 2 shows the kernel estimation of the probability density functions (PDFs) of simulated returns.

Conclusion

By adding smart traders we try to improve the original heterogeneous agent's model so that it provides a closer description of real markets. The main result of the simulations is that the probability distribution functions of the price deviations change significantly with an increasing number of smart traders in the model, and they also change significantly when changes in sentiment are introduced. We also use the Hurst exponent to measure the persistence of the price deviations and we find that the Hurst exponent increases significantly with the number of smart traders in the simulations (see Figure 3). This means that the introduction of the smart trader's concept into the model results in significantly higher persistence of the simulated price deviations. On the other hand, the introduction of changing sentiment in the proposed form does not change the persistence of the simulated prices significantly.

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Holons for Analysis, Modelling and Simulation of Complex Systems

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Nobel Laureate Herbert Simon states: "Empirically a large proportion of the complex systems we observe in nature exhibit hierarchic structure." Starting from this assertion we developed a novel approach for designing and implementing complex systems combining the multi-agent approach and the holonic social organization perspective.

This project is a collaboration between the Palermo department of the ICAR institute of the Italian National Research Council (CNR), and the SeT laboratory of the University of Belfort-Montbelliard (UTBM), France. It started in 2007 and it is still running today. This collaboration was the opportunity for several exchanges, and one researcher from ICAR/CNR spent a year and a half in Belfort within this activity.

Our starting point was that in the past, researchers have deployed a considerable effort in the analysis, modelling and implementation or simulation of complex systems. Their work improved the state of the art in understanding and designing software capable of simulating such systems. However, many of these systems fail to fully represent the real system they model. The aim of this project was to provide a natural, versatile and scalable representation dimension for such systems. Such a goal was pursued by adopting the holonic paradigm in the context of multi-agent systems (MASs).

MASs naturally emphasize the importance of system properties such as autonomy, proactivity, social abilities and self-organization. These properties mean MASs are an obvious candidate for a paradigm for the design of complex systems. Indeed, this paradigm proposes new strategies for the analysis, modelling and implementation of such systems. Its elementary constituents are called 'agents', ie software entities which exhibit autonomous and flexible behaviours.

Complex systems are characterized by a large number of entities in interaction, exhibiting emergent behaviours. Nobel Laureate Herbert Simon states: "Empirically a large proportion of the complex systems we observe in nature exhibit hierarchic structure. On theoretical grounds we could expect complex systems to be hierarchies in a world in which complexity had to evolve from simplicity." Simon (1996)

This raises the question: if nature has selected this path, should scientists trying to model complex systems privilege it too? In this project we are interested in these hierarchical structures to analyse and model complex systems. More precisely, we explore the requirements and consequences of modelling complex systems using hierarchically composed agents.

In 1967 Arthur Koestler coined the term holon as an attempt to conciliate holistic and reductionist visions of the world. A holon represents a part-whole construct that can be seen both as a component of a higher-level system and as a whole composed of other holons as substructures.

We apply holonic-related concepts to systems which exhibit a kind of hierarchical structure, or which there are many types. Indeed, simulations of